КОРОТКІ ПОВІДОМЛЕННЯ ТА НОТАТКИ З ПРАКТИКИ

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Clinical case of reconstruction of gunshot foot injury using the alt free flap technique

I. P. Khomenko [1, 2], M. L. Ankin [1, 2], V. O. Ladyka [2], V. V. Nehoduiko [4], S. V. Tertyshnyi [3], I. O. Balaban [3]

[1] National Academy of Medical Sciences of Ukraine, Kyiv
[2] Shupyk National Healthcare University of Ukraine, Kyiv
[3] Military Medical Clinical Center of the Southern Region, Ministry of Defense, Odesa. Ukraine
[4] Military Medical Clinical Center of the Northern Region, Ministry of Defense, Kharkiv. Ukraine

With the onset of the full-scale war in Ukraine, the number of wounded individuals with soft tissue defects has significantly increased, necessitating the use of plastic surgery techniques for wound closure. However, to date, this surgical treatment method has not been widely adopted in military medicine due to the limited number of qualified specialists, the technical complexity of such procedures, and the need for specialized surgical department resources. Objective. To explore alternative surgical treatment approaches for patients with extensive foot defects using a free anterolateral thigh (ALT) flap to improve the functional, aesthetic, and weight-bearing properties of the foot. Methods. A single-stage reconstructive plastic surgery using a free composite flap (ALT free flap) was performed on a 49-year-old male serviceman due to the long-term consequences of a mine-blast injury. The injury resulted in a chronic combined non-healing granulating wound on the plantar surface of the right foot, comprising 60 % hypertrophic keloid scar tissue and 40 % non-healing granulating wound. To restore the anatomical integrity of the affected soft tissue, a free anterolateral perforator thigh flap (Anterolateral thigh flap) was used. Results. The transferred ALT flap successfully integrated into the plantar surface of the foot without complications. In the early postoperative period, venous congestion and epidermolysis were observed. This clinical case demonstrates that reconstructive plastic surgery using an ALT flap is an optimal approach for restoring the function of the damaged foot. Conclusions. The use of a free ALT flap addresses the issue of insufficient local donor site availability for volumetric, aesthetic, and functional reconstruction. Additionally, it enables microsurgical anastomosis at a favorable distance from the compromised area with impaired tissue trophism, which helps reduce technical difficulties and the rate of postoperative complications.

Через повномасштабну війну в Україні суттєво зросла кількість поранених із дефектами м'яких тканин, що зумовило необхідність використання методик пластичної хірургії для закриття ран. Анатомічне розташування та розмір певних травм часто унеможливлюють застосування місцевого донорського місця, що підкреслює важливість вільної шкірної пластики або трансплантації цілого комплексу тканин. Мета. Дослідити альтернативні хірургічні підходи до лікування пацієнтів із обширними дефектами стопи з використанням вільного передньолатерального клаптя стегна для покращення функціональних показників кінцівки. Методи. Одноетапна реконструктивна пластична операція з використанням вільного композитного клаптя (вільний клапоть ALT) проведена 49-річному військовослужбовцю через наслідки мінно-вибухової травми. Ушкодження призвело до утворення хронічної комбінованої рани на підошовній поверхні правої стопи, що складалася з 60 % гіпертрофічної келоїдної рубцевої тканини та 40 % рани, яка не загоювалася. Для відновлення анатомічної цілісності уражених м'яких тканин використано вільний передньолатеральний перфорантний клапоть стегна. Результати. Перенесений ALT-клапоть успішно інтегрувався в підошовну поверхню стопи без ускладнень. У ранньому післяопераційному періоді спостерігалися венозний застій та епідермоліз. Висновки. Використання вільного ALT-клаптя вирішує проблему недостатності. функціональної реконструкції. Крім того, це дозволяє мікрохірургічне анастомозування на сприятливій відстані від ураженої ділянки з порушенням трофіки тканин, що допомагає зменшити технічні труднощі та частоту післяопераційних ускладнень. Ключові слова. Вільний клапоть, дефекти рани, передньолатеральний клапоть стегна, вогнепальна рана, реконструкція.

Keywords. Free flap, wound defects, anterolateral thigh flap, gunshot wound, reconstruction

Introduction

Structure of combat trauma and reconstruction of lower limb injuries

Lower limb injuries continue to dominate the structure of combat trauma [3]. Several factors contribute to this: the lack of widespread use of personal protective equipment for the lower extremities (particularly the foot), the active use of mine-explosive weapons in combat operations, and the relatively large surface area of the lower limbs, making them more susceptible to injury.

Among the various mechanisms of trauma encountered in military conflicts, mine-explosive injuries rank first in both frequency and severity. Moreover, current trends indicate an increasing prevalence of this type of injury in the future. Mine-explosive trauma is one of the most severe and specific forms of combat injury, often involving multiple anatomical regions — typically two or three, but sometimes even more. The extensive damage associated with these injuries, the inherent tendency of gunshot wounds to become infected, and the frequent severe impairment of local blood supply and innervation all contribute to prolonged treatment and recovery periods for affected patients.

The foot plays a critical role in human mobility, providing support, movement, shock absorption, and balance. Reconstructive surgery on this segment of the lower limb aims to restore these functions as fully as possible, a challenging task when dealing with gunshot wounds as the etiological factor of injury [7]. In recent years, one of the most promising surgical approaches for treating such injuries has been the use of complex polystructural (chimeric) flaps, which incorporate multiple tissue types with an axial vascular supply [2, 9–11]. These procedures can be performed using either pedicled (non-free) flap transposition or free flap microsurgical autotransplantation.

The advantage of axial flaps, which were experimentally and clinically validated as early as the 1970s [10], lies in their ability to provide large and morphologically diverse tissue complexes for transplantation to almost any region of the human body. It is important to note that the foot, as the most distal segment of the lower limb, presents unique challenges for plastic wound closure. Additionally, the clinical scenario may be complicated by periwound tissue transformation [4, 5], which in some cases makes the use of local axial flaps virtually impossible. This necessitates consideration of axial flaps harvested from distant donor sites, which not only offer better tissue quality but also reduce trauma to the recipient site, thereby minimizing functional impairments.

Experience gained by the global reconstructive-plastic surgery community has shown that when designing free flaps for lower limb soft tissue reconstruction, the vascular pedicle should be of sufficient length (at least 8.0 cm) and diameter (approximately (2.0 ± 0.56) mm). These requirements are most easily met by harvesting free polystructural tissue complexes based on the radial artery, thoracodorsal artery, or lateral circumflex femoral artery. The vascular pedicle characteristics of these donor sites enable microvascular anastomosis to be performed at a considerable distance from the compromised zone, which is often affected by trophic disturbances and gunshot-related soft tissue transformation. Specifically, the anterolateral thigh (ALT) free flap used in this study can be designed with a vascular pedicle length of up to (16 ± 1.5) cm, incorporating a large skin-fascial component (up to 25×10 cm), a substantial portion of the vastus lateralis muscle (up to 500 cm^3), or a combination of these elements.

Objective: the aim of this study is to explore alternative surgical treatment options for patients with extensive foot defects by utilizing an anterolateral thigh (ALT) free flap to enhance the functional, aesthetic, and weight-bearing capabilities of the foot.

Materials and methods

During the full-scale war in Ukraine, on May 3, 2022, a 49-year-old Ukrainian Armed Forces serviceman sustained a mine-explosive injury while maneuvering on the battlefield in Donetsk region. The injury resulted from the detonation of a PFM-1 «Lepestok» anti-personnel mine (Fig. 1), causing a gunshot fragmentation wound to the right foot, a gunshot fracture of the calcaneus and cuboid bones, extensive soft and bone tissue defects, and hemorrhagic shock of grade-1.

The patient was evacuated from the site of injury and transported within two days to a Level III medical facility. He underwent two months of inpatient treatment in Ministry of Defense healthcare institutions, including staged necrosectomies. During the final surgical intervention, the wound defect on the plantar surface of the right foot was closed using a split-thickness skin graft.

Over the following two years, the patient experienced persistent numbness in the heel area, swelling and cyanosis of the foot, and limping on the right lower limb during prolonged physical exertion. In the past year, while wearing personal protective equipment that increased axial loading, he reported recurrent skin tears on the weight-bearing surface

of the right foot, circular foot infiltration, and chronic pain syndrome.

The patient was referred for further examination and treatment at the Military Medical Clinical Center of the Southern Region of the Ukrainian Armed Forces. He was evaluated by a surgical specialist and subsequently hospitalized in the Department of Reconstructive and Restorative Surgery.

During the examination, the presence of a wound on the postoperative scar of the plantar surface of the right foot was noted (60 % in the form of a hypertrophic keloid scar and 40 % in the form of a sluggishly granulating wound) (Fig. 2). At the time of the examination, the wound was covered with a scab, with a small amount of wound discharge and almost no signs of inflammation. The periwound tissues were transformed due to inflammatory-destructive changes.

Due to the lack of a loco-regional donor reserve, the possibilities of transplanting a tissue complex from distant areas are being actively considered. Taking into account the existing pathomorphological transformation and data from additional research methods, a decision was made to perform a one-stage reconstructive surgical intervention using a free anterolateral skin-fascial thigh flap harvested from the unilateral side.

During the preoperative preparation, the patient underwent standard clinical examinations (complete blood count, biochemical blood analysis, coagulation profile, blood type and Rh factor determination, serological markers for viral hepatitis B and C, HIV, syphilis, ECG, and chest fluorography). Additionally, specialized diagnostic methods were performed, including X-ray imaging of the right foot with visualization of the ankle joint and distal epiphyses of the tibia (Fig. 4), angiography of the vessels of the right lower limb (Fig. 3), dynamic digital thermography (Table, Fig. 7), and ultrasound Doppler sonography of skin perforators of the lateral circumflex femoral artery.

As part of the preoperative preparation, the wounded soldier was also examined by a physician to identify any comorbid conditions. The surgery was performed under combined anesthesia (spinal anesthesia + intravenous sedation). The total duration of the surgical procedure was 7 hours, while the anesthesia time was — 7 hours and 15 minutes. The intraoperative blood loss amounted to 100 ml.

The surgery was performed by an extended team of four surgeons, allowing the division of work between the donor and recipient sites. Throughout the procedure, a warm and moist environment in the surgical wound was maintained by regularly instilling saline solution. Intraoperative ultrasound

Fig. 1. Local Condition of the Right Foot at the Time of Initial Medical Care During Medical Evacuation on May 3, 2022: The plantar surface of the right foot exhibited a defect with a gunshot fracture of the calcaneus and cuboid bones. The wound defect measured 15×12×6 cm, with torn and infiltrated wound edges of a cyanotic-burgundy color. The wound bed consisted of soft tissues in shades of gray and pale pink, interspersed with brown and black areas, indicating necrotic transformation (eschar formation)

Fig. 2. Local status of the right foot at the time of admission to the Department of Reconstructive and Restorative Surgery of the Military Medical Clinical Center of the Southern Region on December 10, 2024: a hypertrophic keloid scar measuring 5×4.5×0.8 cm; along the medial surface of the calcaneus, there is a chronic sluggishly granulating wound with a diameter of 3.5 cm with calloused edges. The surface is covered with multilayered plaques of desquamated epidermis of a gray-yellow color

Fig. 3. Angiography of the right lower limb: a main-type blood flow with satisfactory contrast filling of the anterior and posterior tibial arteries. A — anterior tibial artery, B — posterior tibial artery

Fig.4. X-ray of the right foot: defects of calcaneus and cuboid bones with the signs of consolidation

audiodopplerographic monitoring was periodically performed to assess the pulsation of the perforator artery of the harvested flap and the anastomosis.

In the postoperative period, daily wound dressings were carried out with clinical and dynamic multimodal monitoring, including audiodopplerography and thermometric assessment of flap viability and surrounding tissue condition.

On the second postoperative day, venous congestion of the flap was observed during dressing changes, and on the third day, epidermolysis affected the entire surface of the flap. However, clinical, morphological, and thermometric evaluations confirmed flap viability. Throughout the early postoperative period, the tension test remained positive, with capillary refill time up to 5 seconds.

On the 10th postoperative day, every other suture securing the flap was removed, with complete suture removal on the 13th day. The sutures of the donor site were removed on the 12th postoperative day. The patient was discharged on the 19th postoperative day for early adaptive rehabilitation.

Surgical technique description

Flap Design

The blood supply of the anterolateral thigh (ALT) flap is provided by septocutaneous or musculocutaneous vessels branching from the descending branch of the lateral circumflex femoral artery (Fig. 5).

During flap marking on the lateral surface of the thigh, the guaranteed zone of these vessels was determined by drawing a line from the anterior superior iliac spine to the upper outer border of the patella. By marking the midpoint of this line and outlining a circle with a radius of 3 cm, thermographic and Doppler ultrasound monitoring was performed to precisely identify terminal blood supply at the epidermal level.

The second step in the preoperative period involved measuring and calculating the future defect area on the plantar surface of the right foot (considering the excision of scar tissue), and then transferring these dimensions onto the lateral surface of the right thigh. An additional 10 % was added to compensate for possible tissue shrinkage.

Flap Elevation

Following the pre-marked incision line, a scalpel was used to dissect the skin, subcutaneous fat, and deep fascia along the medial border of the flap. Step by step, in accordance with the classical ALT free flap dissection technique, soft tissue dissection was performed to expose the previously identified perforator vessel and accompanying veins.

All small branches were ligated and clipped. The vascular pedicle was clipped and divided at the proximal level, forming a free fasciocutaneous flap with axial blood supply, measuring 20×7×1.5 cm and a vascular pedicle length of 12 cm.

The donor site was closed with primary tension sutures using a continuous intradermal Holsted suture without excessive tension.

Flap Transfer

In the recipient area, excisional surgical debridement was performed, followed by irrigation with 3 % hydrogen peroxide and Decasan solutions.

The free ALT flap was transferred to the defect area, and a microvascular anastomosis was performed using an end-to-side technique with a branch of the anterior tibial artery and accompanying veins, utilizing the Coupler system [10].

The flap was then secured to the wound defect in layers with interrupted sutures, fixing the dermis separately using Donati sutures. The subflap space was drained with rubber drains, covered with petroleum jelly gauze, and dressed with aseptic bandages. Additional orthotic fixation of the foot was applied, maintaining an elevated position at 10° relative to the horizontal body axis.

Throughout the procedure, meticulous hemostasis was ensured using electrocautery and a pneumatic tourniquet.

All stages of ALT free flap elevation and fixation were continuously monitored using thermography and Doppler ultrasound.

Results

The transplanted tissue complex successfully integrated into the recipient area, and the postoperative wound at the donor site healed by primary intention.

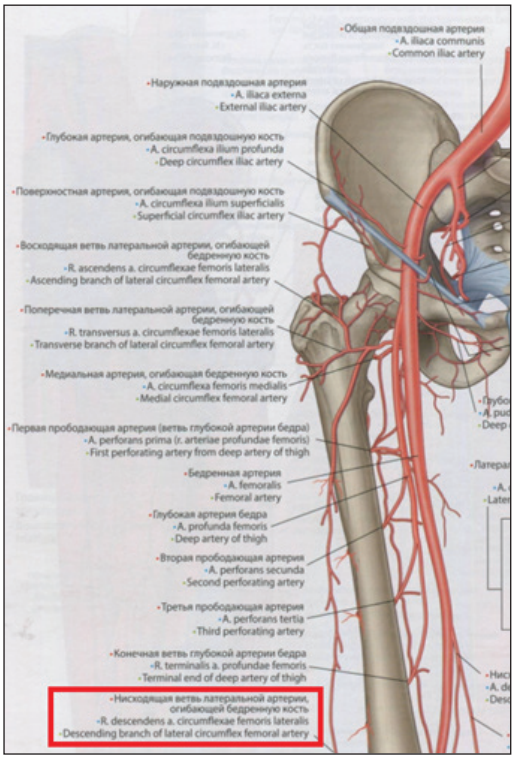

Fig. 5 Illustration of femoral arteries (anterior view). Gray's Anatomy Atlas, 2nd edition, 2020

In the early postoperative period, signs of venous congestion and epidermolysis of the transplanted flap were observed, but without necrosis (Fig. 5).

Postoperatively, dynamic monitoring was conducted using digital thermography (DCT) and Doppler ultrasound:

– every hour during the first 24 hours;

– every 2 hours on the second postoperative day;

– every 4 hours on the third postoperative day.

Fig. 6. Photographs of the right foot in lateral and frontal projections. Local status on the 7th postoperative day: signs of partial infiltration and venous congestion of the flap

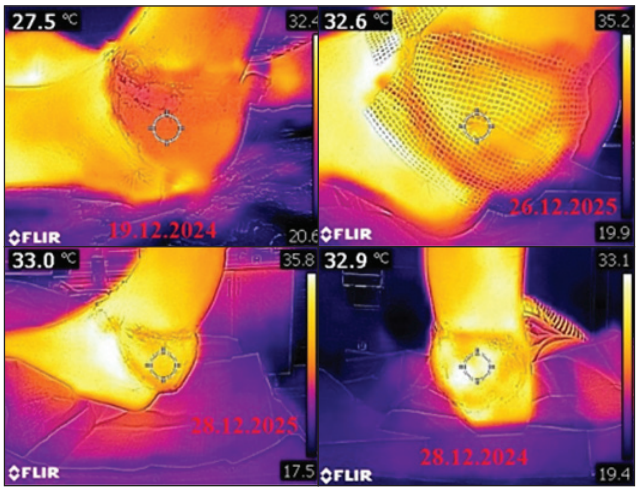

Fig. 5. Thermography of the Flap

Table

Indicators of thermographic monitoring of flap viability

Date	Indicators of Infrared Thermography of the Flap, °C
19.12.2024	27.5
26.12.2024	32.6
28.12.2024	33.0

At the time of this report, the patient has been discharged from the hospital for medical leave, with restored general and local status. The wound has healed by primary intention.

Conclusions

The use of a free ALT flap allows for solving the problem of the absence of a loco-regional donor reserve (in terms of volumetric, aesthetic, and functional restoration). Additionally, it enables microvascular anastomosis at a favorable distance from the compromised pathological area with impaired trophism, which further helps reduce technical difficulties and the percentage of postoperative complications.

This flap can be formed and transplanted in a single-stage procedure to the recipient zone of all parts of the foot.

Conflict of interest. The authors declare no conflict of interest.

Prospects for further research. Inclusion of the use of the method of remote infrared thermography in the postoperative period to determine the course of wound regeneration, as well as monitoring the health of servicemen after pathological conditions detected during thermographic examination and appropriate treatment. Study of the health of servicemen after mine-explosive injuries, complications after diseases of the bronchopulmonary system, neuropathy. The information base of thermographic visualizations of detected pathological conditions will be expanded, which can be used by doctors of almost all specialties in medical practice. Include the use of plastic surgery methods for wound closure in military medicine. Reconstruction of soft tissue defects associated with gunshot wounds. Study of alternative surgical approaches to the treatment of patients with extensive defects.

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Author's contribution. Each of the authors took an equal part in determining the topic of the article, in selecting patients, conducting thermographic examinations, analyzing and discuss-ing the results of the work, processing literary sources and pre-paring the obtained materials for publication.

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КЛІНІЧНИЙ ВИПАДОК РЕКОНСТРУКЦІЇ ВОГНЕПАЛЬНОЇ ТРАВМИ СТОПИ З ВИКОРИСТАННЯМ ТЕХНІКИ ВІЛЬНОГО КЛАПТЯ

І. П. Хоменко [1, 2] , М. Л. Анкін [1, 2], В. О. Ладика [2], В. В. Негодуйко [4], С. В. Тертишний [3], І. О. Балабан [3]

[1] Національна академія медичних наук України, Київ
[2] Національний університет охорони здоров'я України імені П. Л. Шупика, Київ
[3] Військово-медичний клінічний центр Південного регіону. Міністерство оборони України, Одеса
[4] Військово-медичний клінічний центр Північного регіону. Міністерство оборони України, Харків

✉ Igor Khomenko, MD, D.Sci., Prof.: hip65@ukr.net; https://orcid.org/0000-0002-8199-5083
✉ Mykola Ankin, MD, D.Sci., Prof.: m.ankin@ukr.net; https://orcid.org/0000-0001-9795-0931
✉ Viktoriya Ladyka, MD, PhD: ladika084@gmail.com; https://orcid.org/0000-0002-3796-428X
✉ Volodymyr Nehoduiko, MD, PhD: vol-ramzes13@ukr.net; https://orcid.org/0000-0003-4540-5207
✉ Serhii Tertyshnyi, MD, D.Sci.: tertyshnyi.sergey@gmail.com; https://orcid.org/0000-0002-4949-5409
✉ Ihor Balaban, MD: igorbalaban726@gmail.com; https://orcid.org/0009-0002-4391-3769